

# MODULATING A POLYCHROMATIC IMAGE BY A 2<sup>ND</sup> IMAGE PLOTTED AGAINST SATURATION AND A 3<sup>RD</sup> IMAGE PLOTTED AGAINST LIGHTNESS – PROGRAM hisplot

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### Overview

There are two main reasons to modulate one attribute by another. The first application is when the two attributes form components of a 2D vector such as dip magnitude and dip azimuth, envelope and instantaneous phase, or spectral peak magnitude and spectral peak phase, whereas the third is the original seismic amplitude. The second application is when we wish to modulate an attribute vector or an attribute crossplot by another that provides a measure of confidence. For example, we may wish to map volumetric dip azimuth and magnitude by coherence.

The AASPI software allows several ways to do this. Program **hlplot** modulates an attribute plotted against a polychromatic color bar by a second against lightness. Program **hsplot** modulates an attribute plotted against a polychromatic color bar by a second against saturation. Program **hlsplot** allows two levels of modulation. Program **corender** provides an interactive means to modulate one attribute by one or two others.

## **Computation Flow Chart**

Program **hisplot** reads in three attribute volumes and outputs a composite volume, a color legend, a histogram, and a suite of multiplexed colorbars that can be used to load the composite volume into the more common interpretation workstations software products.



### Output file naming convention

Output file description	File name syntax	
Composite attribute	Hue_axis_title_vs_saturation_axis_title_vs_lightness_title_unique_project_name.H	
Color legend (2D colorbar)	hlsplot_color_legend_ <i>hue_axis_title_</i> vs_ <i>saturation_axis_title_</i> vs_ <i>hue_axis_title_unique_p</i>	
2D histogram	hlsplot_histogram_hue_axis_title_vs_saturation_axis_title_vs_hue_axis_title_unique_proj	
Multiplexed 1D		
colorbars	hls_colorbar.alut, hls_colorbar.CLM, etc	
Program log		
information	hlsplot_ <i>unique_project_name</i> .log	
Program		
error/completion	hlsplot_ <i>unique_project_name</i> .err	
information		

Program **hisplot** will always generate the following output files:

where the values in red are defined by the program GUI. The errors we anticipated will be written to the *\*.err* file and be displayed in a pop-up window upon program termination. These errors, much of the input information, a description of intermediate variables, and any software traceback errors will be contained in the *\*.log* file.

### Invoking the hlsplot GUI

To invoke program **hlsplot**, on the **aaspi\_util** GUI select *Display Tools* and then select **hlsplot** on the drop-down menu:

🗙 aaspi_util GUI - Post Stack Utilitie	es (Release Date: 15_May_2022)		- 0	×
] <u>F</u> ile Single Trace Calculatio	ons Spectral Attributes G	eometric Attributes Formation Attributes Volumetric Classification Image	Processing	Help
Attribute Correlation Tools	Display Tools Machine Lear	ning Toolbox Surface Utilities Well Log Utilities Other Utilities Set AASPI	Default Para	meters
SEGY to AASPI format conversion format (mult SEGY to AASPI - Convert Pc	corender 4D spectral data viewer hlplot hsplot	n AASPI QC Plotting AASPI Workflows AASPI Prestack Utilities		
2D SEG-Y Line rather than a SEGY-format input file nam	hlsplot rab can alot Modulate an attribute plotted a second attribute plotted a a third against Lightness			
SEGY header utilities: AASPI binary file datap Absolute file name followed	generate_roses graph_plot by a '/	header content SEGY header ut 29925/AASPI_Data/	ility	

#### The following GUI opens up:

]	X aaspi_hlsplot GUI (Release Date: 24_May_2022)		- 0	×
	Eile			Help
		ues from 0 to {hue*lightness*saturation} which ndmark, Voxelgeo, geomodeling, Kingdom, and SEP		
	Hue			
1a	Attribute against the hue axis (*.H):	mes6/marf2925/projects/GSB_AAPG/dip_azimuth_GSB_AAPG_0_broadband.H Browse		
1b	Title on Hue Axis:	Azimuth 1f Re-scan Hue		
1c	Range of Hues:	cyclical [-180 +180]		
1d	Attr. value to be plotted against min_hue:	-180		
	Attr. value to be plotted against max_hue:	180		
	Lightness			
2a	Attribute against the lightness axis (*.H):	2925/projects/GSB_AAPG/energy_ratio_similarity_GSB_AAPG_0_broadbagd.H_Browse		
2b	Title on Lightness Axis:	Coherence 2f Re-scan Ligh	ntness	
2c	Attr. value to be plotted against min_lightness:	0.6		
2d	Attr. value to be plotted against max_lightness:	1		
2e	Min lightness value (0.0 => black):	0		
	Max lightness value (1.0 => white):	0.7		
	Saturation			
3a	Attribute against the saturation axis (*.H):	s6/marf2925/projects/GSB_AAPG/dip_magnitude_GSB_AAPG_0_broadband.H Browse		
3b	Title on Saturation Axis:	Dip 3f Re-scan Sa	uration	
3c	Attr. value to be plotted against min_saturation:			
3d	Attr. value to be plotted against max_saturation:	10		
3e	Min saturation value (0.0 => shades of gray):	0		
	Max saturation value (1.0 => pure colors):	1		
4	Maximum number of colors 256 for petrel, geoviz, geomodeling, seisworks) (230 for Kingdom Suite):	256		
5	Color map size: (H*L*S <= 256)	H: 12 * L: 5 * S: 4		
6	Plot title:	Azimuth vs_Dip_vs_Coherence		
<b>F</b> SY	Composite Output File (*.H):	th_vs_Dip_vs_Coherence_GS8_AAPG.H		
······	Colorbars to Generate			
	GeoFrame	(.iesx) 🗖 Landmark (.landmark .cl2) 🗖 VoxelGeo (.color) 🗖 Geomodeling (.geomodeli	ng)	
<u> </u>	1	(.cmp) 🗆 Kingdom (.CLM) 👘 GeoProbe (.gpc) 🗖 Shell internal 1D cmap (.cr		
	□ Shell internal 2D cmap (.cmap)			
	(c) 2008-2022 AASPI for Linux - authors at Univ.	Oklahoma, Univ. Alabama, Univ. Texas Permian Basin, and SISMO	<u>E</u> xecute h	Isplot

#### Mapping the attributes against the H, L, and S axes

Program **hisplot** plots one attribute against hue (H), a second attribute against lightness (L), and a third attribute against saturation (S). Enter the names of three files to plot against (1a) hue, (2a) lightness, and (3a) saturation. The title of each axis (1b, 1c, 1d) will default to that of the input files. These axis titles will be combined to construct a (6) plot title, and with the unique project name from the hue file the name of the (7) composite output file. Depending on your axis titles you may wish to shorten them for conciseness and/or clarity. The range of the attributes (1c,1d,2c,2d,3c,3d) will be read from the minimum and maximum attribute values on each of the files. In general, azimuth and phase should range from -180° to +180° and strike from -90° to +90° even if the data do not contain all those angles (e.g., a consistent regional dip to the SE). For the

lightness axis, coherence ranges from 0 to 1. I changed the default to be 0.6 to 1. For saturation, the default is to range between 0° to  $+90^{\circ}$ , however, I know my data has few strong dips. To better understand the statistics of the data I click (3f) *Re-scan Saturation*, and obtain the following pop-up window:

X aaspi_completion_status	
n Program Completion Status	
Number of samples analyzed = 962334   min_amplitude = 0.000000E+00   max_amplitude = 4.3.91674   mean_amplitude = 4.578950   rms_amplitude = 3.133010   2.000000 percentile =   98.00000 percentile =   13.24045   Normal completion. routine extract_data_statistics	

where I see the data range between 0° and 43.9° with the 2<sup>nd</sup> and 98<sup>th</sup> percentile at 0.6° and 13.2°. I therefore set my limits (3c and 3d) to be 0° and 10°.

In general, you should not need to change the mappings 1d, 2d, and 3d, unless you want to reverse a given color axis.

#### Defining the 3D color map and color depth

The more commonly used commercial software have been established for over a decade. For this reason, most are limited to using no more than 256 colors in a given image (Kingdom Suite only allows 240 colors, with the remaining 16 used for picks and legends). Through opacity and/or RGB blending (as in AASPI program corender) many of these packages can allow 256×256=65,536 or even 256×256=16,777,216 colors, although the associated color tables are not explicitly created. Using more colors to define the same range of colors is referred to as *color depth*.

For the example above, I use the default (5) *Color map size* of 256. I use the default parameters of (5) *nhue*=12, *nlightness*=5, and *nsaturation*=4, giving a total of 240 colors. The remaining 16 colors will be set to white, which will also serve as a background color for dead traces and mute zones. I click *Execute hlsplot* and wait for a suite of images to appear.

#### The 3D color legend

First, the 3 color axes are plotted against each other in a rectangular volume. Here, I display the five panels corresponding to coherence values of 0.6, 0.7, 0.8, 0.9, and 1 which range from black, through midnight colors, through "pure" colors, to pastel colors. If the maximum value of lightness was set to 1.0, the last panel would be white, thereby making all dip and azimuth values look the same.



Note in each constant lightness plane the four levels of saturation (where the lowest, zero saturation level is gray) and the 12 levels of hue, which wrap around.

### The 3D color wheel (when the attribute plotted against hue is cyclic)

Because the colorbar used for the hue axis is cyclic, the software knows to plot it as a color wheel (or cylinder in three dimensions):



The color wheels are plotted using the **aaspi\_plot** utility which is designed to display seismic amplitude and attribute data. I've annotated the image in PowerPoint to give a more explicit definition of the color wheel:



#### 3D histograms

As part of the color display, each triplet is assigned to a bin (which range from a value of 0 to a value of *max\_color-1*). It is therefore a simple matter to define how many voxels map to a given bin, giving a 3D histogram.



#### 3D histogram wheels

When an attribute is plotted against saturation using cyclic color bar, program hlsplot will also plot the histogram as a series of wheels. In this image we see that the most common orientation exhibits high coherence and dipping gently to the Southeast.



#### Plotting the composite image

The **hisplot** python script will using program crop to decimate the data vertically and slice to generate time slices to quality control the results. Here is a representative time slice using the parameters shown in the GUI above:



## Adding greater color depth

The default settings will be set to give 240 colors which can be loaded into almost all commercial interpretation software packages. However,

Now, lets change the number of colors on each axis to be 64:



When I execute the program, I obtain a warning message that requires me to change the maximum number of colors

Warning	
Number of requested colors =262144 exceeds maximum number of colors Please decrease colors per axis or increase maximum number of colors	=256
OK	

where 64×64×64=262,144. I need to add one extra color for background white, so my GUI now looks like this:

Maximum number of colors (256 for petrel, geoviz, geomodeling, seisworks)	262145
(256 for petrel, geoviz, geomodeling, selsworks) (230 for Kingdom Suite):	
Color map size: (H*L*S <= 256)	H: 64 * L: 64 * S: 64

I get one more warning message which I can simply ignore:

Warning
Color map size =262145 >256 and will not load into most workstation software
OK

My new 3D color bar and color wheel (cylinder) now has 64 panels. I 'll plot those corresponding to coherence values of 0.6, 0.8, and 1.0:



Let's now examine the impact of changing the color depth. Here is a time slice of the three attributes plotted using 240 colors (the 16 remaining colors were white)



And the same time slice when using 262,145 colors



The best way to compare the two images it to animate between them. There is a significant improvement in lateral resolution of small details provided by the extra levels of coherence and dip magnitude (lightness and saturation).

### References

Marfurt, K. J., 2015, Techniques and best practices in multiattribute display: Interpretation, **3**, 1-24.